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(54) **INVERTER FOR PROVIDING POWER TO LAMP CIRCUIT**

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(*) Notice: This patent issued on a continued prosecution application filed under 37 CFR 1.53(d), and is subject to the twenty year patent term provisions of 35 U.S.C. 154 (a)(2).

Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 80 days.

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Jul. 7, 2003 (TW) .... 92118522 A

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G05F 1/00 (2006.01)
H05B 41/16 (2006.01)

(52) **U.S. Cl.** **315/276**; 315/308; 315/248

(58) **Field of Classification Search** 315/244, 315/94, 86, 395, 169.3, 291, 105, 311, 307, 315/219; 363/134, 135, 165, 166, 20, 65, 363/71; 323/283, 284

See application file for complete search history.

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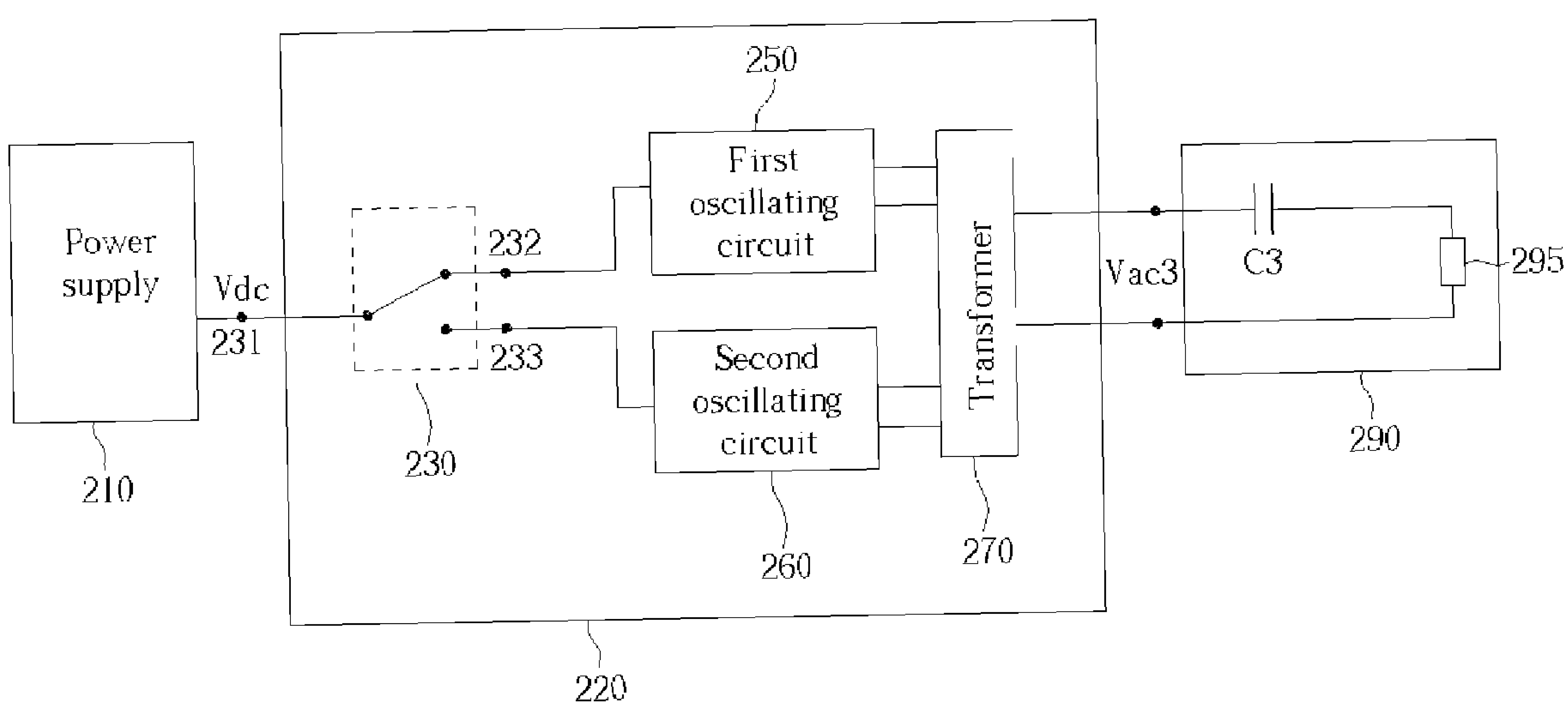
(57) **ABSTRACT**

An inverter for providing power to a lamp coupled to a power supply and a lamp circuit. The inverter can selectively provide the lamp circuit with AC voltages of two different frequencies. The inverter includes: a first switch for passing a DC voltage; a first and second oscillating circuit coupled to the first switch that receives DC voltage and respectively generates a first AC voltage having a first frequency and a second AC voltage having a second frequency; and a transformer coupled to the first oscillating circuit and the second oscillator for transforming the first AC voltage provided by the first oscillating circuit or the second AC voltage provided by the second oscillator into a third AC voltage and passing the third AC voltage to the lamp circuit. The first switch serves to selectively pass the DC voltage to the first oscillating circuit or the second oscillating circuit.

7 Claims, 4 Drawing Sheets



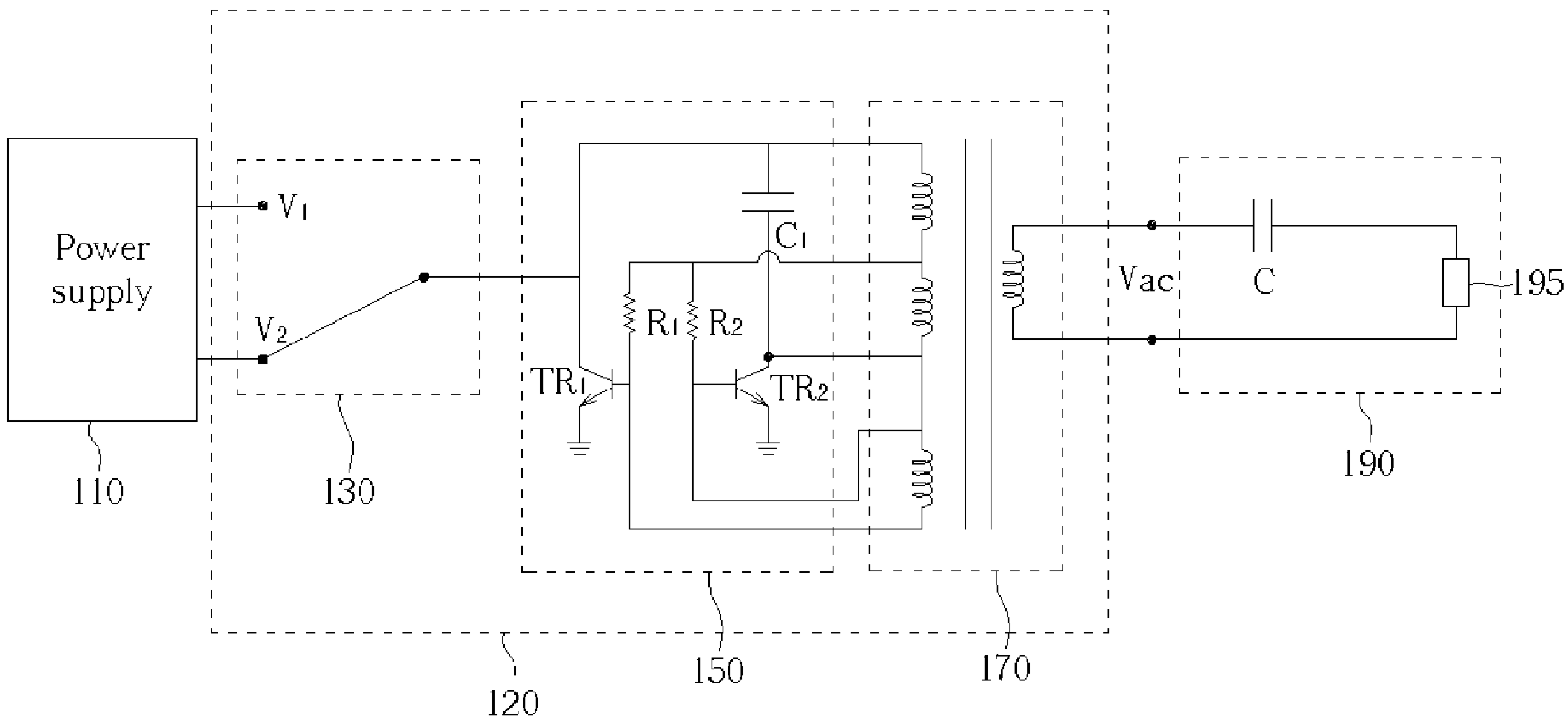


Fig. 1 Prior Art

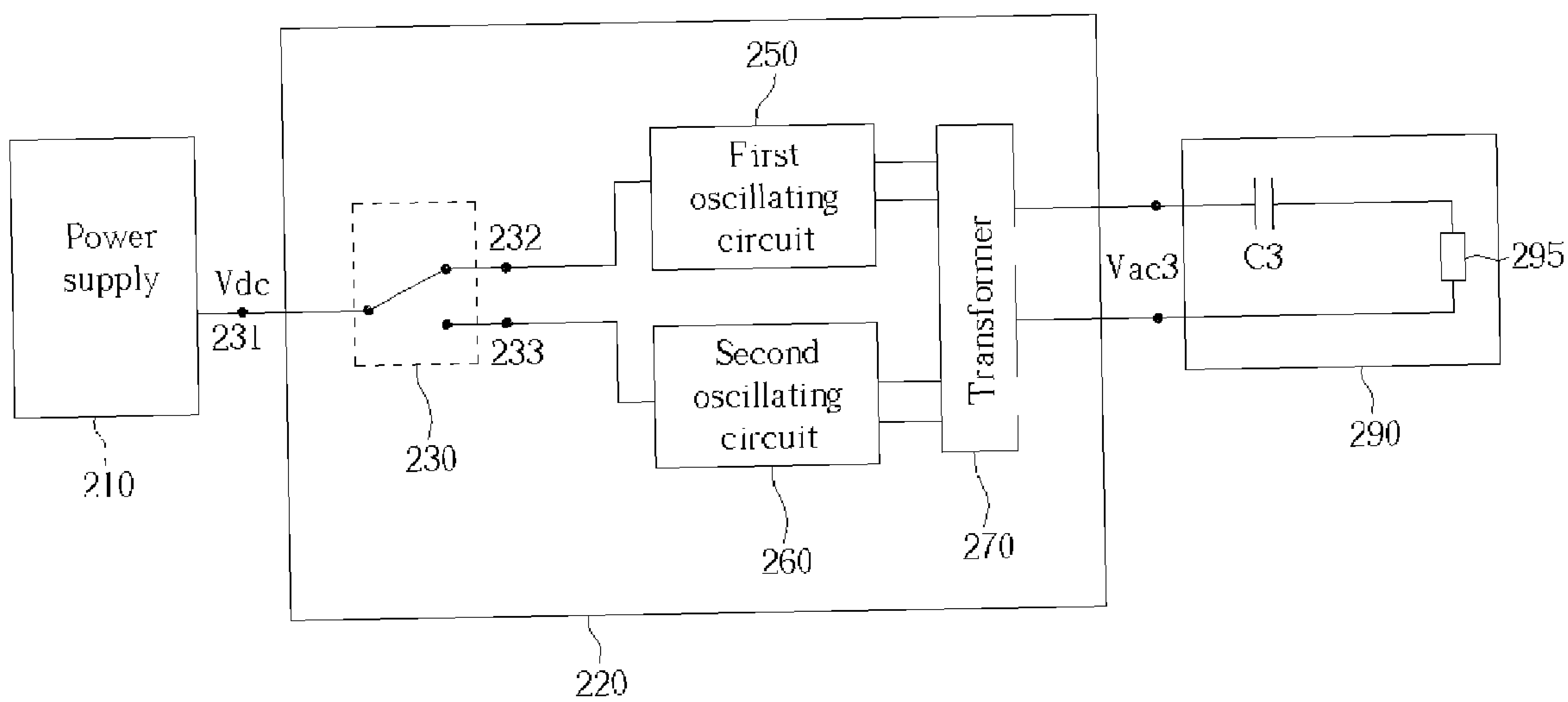
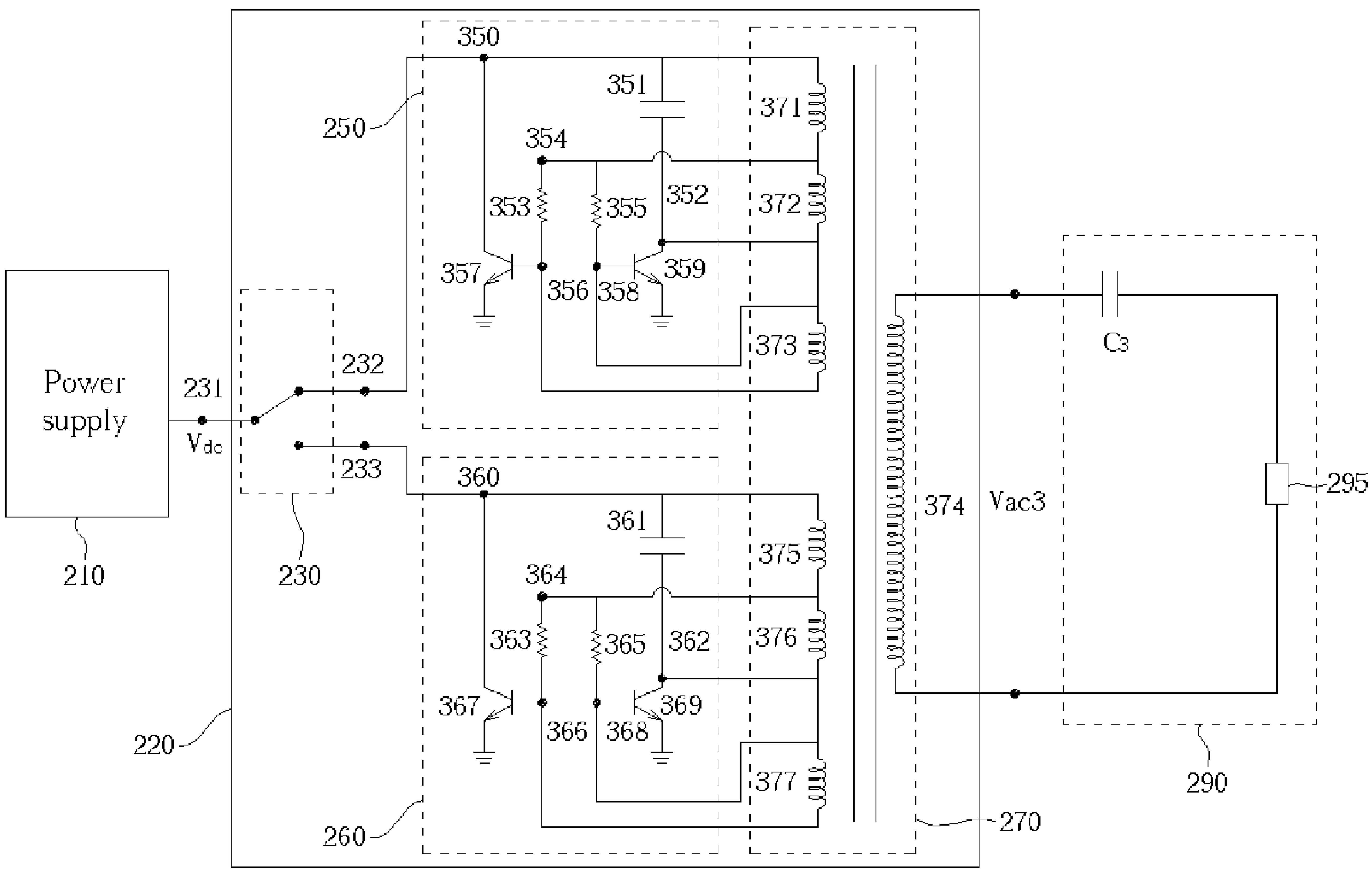

250
First oscillating circuit
Power supply
Vdc
231
232
233
Second oscillating circuit
Transformer
Vac3
C3
295
290
210
230
260
270
220

Fig. 2



Power supply
210
231
Vdc
230
232
233
220
250
260
350
351
352
353
354
355
356
357
358
359
360
361
362
363
364
365
366
367
368
369
371
372
373
374
375
376
377
270
Vac3
C3
295
290

Fig. 3

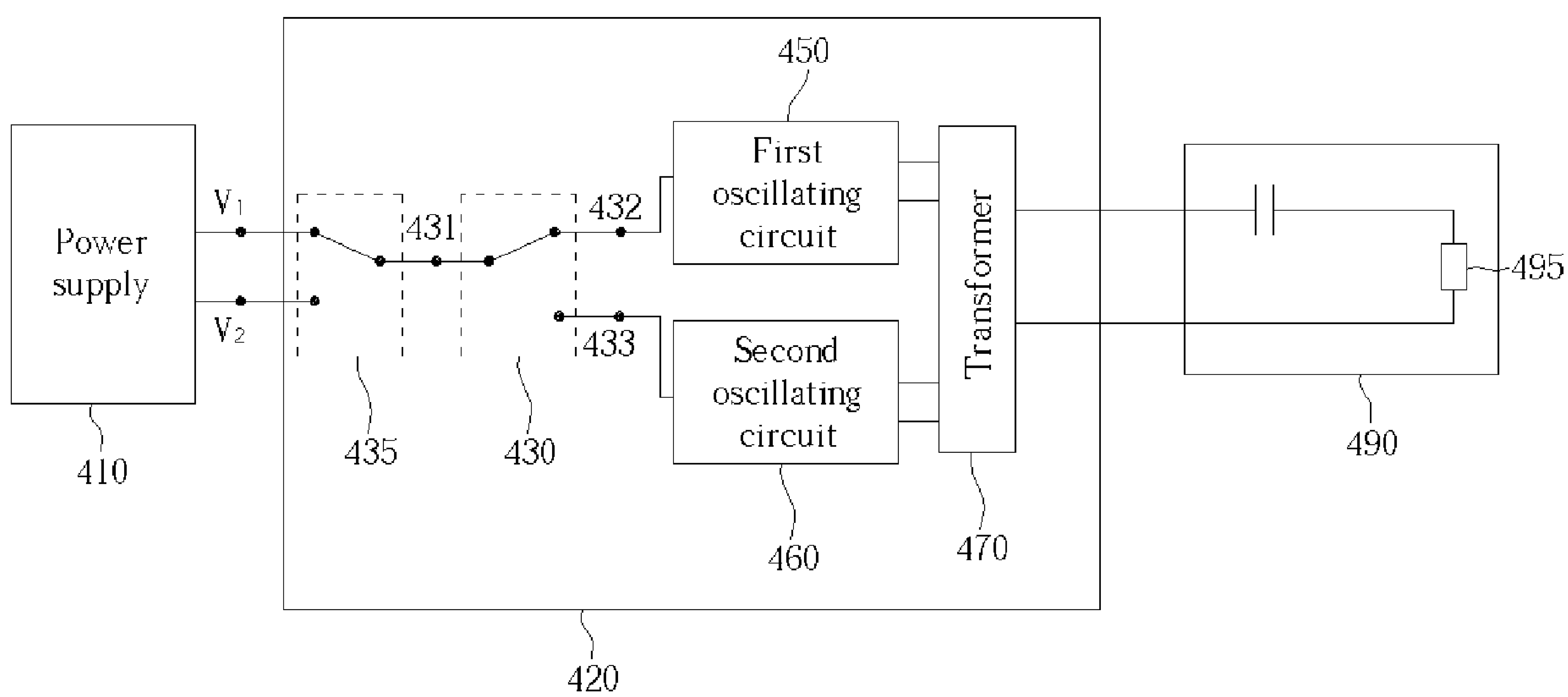

450
First oscillating circuit
Power supply
V1
V2
431
432
433
Transformer
495
Second oscillating circuit
410
435
430
460
470
490
420

Fig. 4

INVERTER FOR PROVIDING POWER TO LAMP CIRCUIT

BACKGROUND OF INVENTION

1. Field of the Invention

The present invention relates to an inverter and more particularly, to an inverter for providing AC voltages having two different frequencies to a lamp circuit.

2. Description of the Prior Art

A high voltage lamp is a common optical part found in devices used in daily life such as scanners and fax machines and need high voltage lamps for operation. Normally, a high voltage lamp is powered by an inverter. The duties of the inverter are to first transform a DC voltage into an AC voltage and then provide the AC voltage to drive the high voltage lamp. A characteristic of the high voltage lamp is that the power requirement of the high voltage lamp during a starting state differs from a normal luminescent state; usually the power required during the starting state is larger than the power required during the normal luminescent state. If the amount of power used in the normal luminescent state is used in the starting state to start the high voltage lamp, it will take too much time for the lamp to start up; hence, the operation of the high voltage lamp will become inconvenient.

As mentioned above, a high voltage lamp uses AC voltage. Assume that for a lamp circuit (including a high voltage lamp) to operate in normal luminescent state, an operating AC voltage is needed for providing suitable power to the lamp circuit. In order to provide more power to the lamp circuit during the starting state, typically, a starting AC voltage having a larger amplitude than the operating voltage is provided to the lamp circuit (normally the frequency of the operating AC voltage is the same as the frequency of the starting AC voltage). Theoretically, the power an AC voltage can provide is determined by the amplitude of the AC voltage; the larger the amplitude of the AC voltage, the more power the AC voltage can provide. If the amplitude of the starting AC voltage is larger than the amplitude of the operating AC voltage, then the starting AC voltage can provide more power than the operating AC voltage and allow the lamp circuit to achieve the goal of a fast start up.

Please refer to FIG. **1** a block diagram of a prior art inverter is illustrated. A power supply **110** provides a first DC voltage **V1** and a second DC voltage **V2**. An inverter **120** includes a first switch **130**, an oscillating circuit **150**, and a transformer **170**. The function of the first switch **130** is to selectively pass **V1** or **V2** to the oscillating circuit **150** as input voltage. The oscillating circuit **150** receives a DC voltage and then oscillates to generate an AC voltage having frequency Fq for outputting. The transformer **170** receives the AC voltage provided by the oscillating circuit **150**, transforms the AC voltage, and outputs the transformed AC voltage to the lamp circuit **190**, which includes a high voltage lamp **195**.

No matter if **V1** or **V2** serves as the input voltage of the oscillating circuit **150**, the frequency of the AC voltage generated by the oscillating circuit **150** will be fixed to the same value (the fixed value is determined by the parameters of elements of the oscillating circuit **150**). When the transformer **170** receives the AC voltage provided by the oscillating circuit **150**, the frequency of the AC voltage will not be changed by the transformer **170**, so the frequency of the AC voltage Vac outputted by the transformer **170** is still Fq.

Assume that when the first DC voltage **V1** serves as the input voltage of the oscillating circuit **150**, the AC voltage Vac outputted by the transformer **170** has an amplitude Vac**1**; when the second DC voltage **V2** serves as the input voltage of the oscillating circuit **150**, the AC voltage Vac outputted by the transformer **170** has an amplitude Vac**2**. Also assume that the AC voltage Vac with amplitude Vac**1** and frequency Fq is the AC voltage suitable for the lamp **195** of the lamp circuit **190** to operate at the normal luminescent state. As mentioned before, in order to provide larger power during the starting state, typically, the amplitude Vac**2** must be larger than the amplitude Vac**1**, and the AC voltage with amplitude Vac**2** must be used during the starting state to achieve the goal of a fast start up.

To sum up, in the prior art for starting the lamp **195** of the lamp circuit **190**, the second DC voltage **V2** is used as input voltage of the oscillating circuit **150**. To satisfy the requirement that the amplitude Vac**2** is larger than the amplitude Vac**1**, the second DC voltage **V2** must be larger than the first DC voltage **V1**. The operation principle is that during the starting state, the first switch **130** passes the second DC voltage **V2** to the oscillating circuit **150** in order to start the lamp **195** quickly; after the starting state is finished (usually when the lamp **195** has reached 80% of its luminosity), the first switch **130** switches to pass the first DC voltage **V1** to the oscillating circuit **150** to operate the lamp **195** at the normal luminescent state.

However, the prior art solution suffers from a few problems. The main problem is that when using the AC voltage with larger amplitude to start up the lamp **195**, the current flow through the lamp **195** is also larger than normal operating current. Normal operating current has little effect on the lifetime of the lamp **195**, but the larger current used during the starting state usually damages the lamp **195** and thereby reducing the lifetime of the lamp **195**. For a high voltage lamp that must be turned on and off frequently, the reduction of the lifetime is a serious problem.

In a device such as a scanner, a fax machine, a high voltage lamp is always a critical component. When the high voltage lamp is damaged, the whole device will also lose normal functionality. So the lifetime of the high voltage lamp in such kind of devices is very important. In conclusion, a main problem of the prior art which uses an AC voltage having larger amplitude to start a high voltage lamp than the amplitude of the AC voltage used during a normal operating state, is that the reduction of the lifetime of the high voltage lamp.

SUMMARY OF INVENTION

It is therefore a primary objective of the present invention to provide an inverter having two oscillating circuits for providing two AC voltages, differing in frequency, to a lamp circuit. So during a normal operating state and a starting state, the lamp circuit uses different AC voltages with different frequencies. The problem of the prior art can be solved.

According to the claimed invention, an inverter is provided. The inverter is coupled between a voltage supply and a lamp circuit for providing AC voltages having two different frequencies to the lamp circuit. The inverter includes: a first switch for passing a DC voltage, a first oscillating circuit coupled to the first switch for receiving the DC voltage and generating a first AC voltage having a first frequency, a second oscillating circuit coupled to the first switch for receiving the DC voltage and generating a second AC voltage having a second frequency, and a transformer coupled to the first oscillating circuit and the second oscillator for transforming the first AC voltage provided by the first oscillating circuit or the second AC voltage provided by the second oscillator into a third AC voltage and passing the third AC voltage to the lamp circuit.

It is an advantage of the claimed invention that the inverter can provide the lamp circuit with AC voltages of two different frequencies. During the normal luminescent state, the AC voltage with the lower frequency can be used in the lamp circuit; during the starting state, the AC voltage with the higher frequency can be used in the lamp circuit to start up the lamp without damaging the lamp.

These and other objectives of the present invention will no doubt become obvious to those of ordinary skill in the art after reading the following detailed description of the preferred embodiment that is illustrated in the various figures and drawings.

BRIEF DESCRIPTION OF DRAWINGS

FIG. **1** is a block diagram of a prior art inverter.

FIG. **2** is an embodiment block diagram of the present invention.

FIG. **3** is an embodiment circuit diagram of the inverter **220** of FIG. **2**.

FIG. **4** is an alternative embodiment block diagram of the present invention.

DETAILED DESCRIPTION

Please refer to FIG. **2** where an embodiment block diagram of the present invention is illustrated. In FIG. **2**, an inverter **220** is coupled between a power supply **210** and a lamp circuit **290**. The inverter **220** is capable of providing AC voltages of two different frequencies to the lamp circuit **290**. The inverter **220** includes a first switch **230**, a first oscillating circuit **250**, a second oscillating circuit **260**, and a transformer **270**.

The first switch **230** is coupled to the power supply **210** for receiving a DC voltage Vdc provided by the power supply **210** from a power-input node **231**. The function of the first switch **230** is to selectively pass the DC voltage Vdc from the power-input node **231** to either the first oscillating circuit **250** or the second oscillating circuit **260**. The first oscillating circuit **250** is coupled to the first switch **230** through a node **232**. When the first switch **230** passes the DC voltage Vdc from the power-input node **231** to the node **232**, the first oscillating circuit **250** receives the DC voltage Vdc and then generates a first AC voltage having a first frequency Fq**1**. The second oscillating circuit **260** is coupled to the first switch **230** through a node **233**. When the first switch **230** passes the DC voltage Vdc from the power-input node **231** to the node **233**, the second oscillating circuit **260** receives the DC voltage Vdc and then generates a second AC voltage having a second frequency Fq**2**.

The transformer **270** is coupled to the first oscillating circuit **250**, the second oscillating circuit **260**, and the lamp circuit **290**. The functions of the transformer **270** is to transform the first AC voltage provided by the first oscillating circuit **250** or the second AC voltage provided by the second oscillating circuit **260** into a third AC voltage Vac3 and then pass the third AC voltage Vac3 to the lamp circuit **290** for the lamp **295** to utilize.

Because the transformer **270** does not change the frequency of the AC voltage, the frequency of the third AC voltage Vac**3** is mainly determined by the first oscillating circuit **250** or the second oscillating circuit **260**. When the switch **231** passes the DC voltage Vdc from the power-input node **231** to the first oscillating circuit **250**, the frequency of the third AC voltage Vac**3** will be the same as the frequency of the first AC voltage outputted by the first oscillating circuit **250**, that is, the first frequency Fq**1**. Assume that at this time the third AC voltage Vac**3** has a first amplitude Vam**1**. When the switch **231** passes the DC voltage Vdc from the power-input node **231** to the second oscillating circuit **260**, the frequency of the third AC voltage Vac will be the same as the frequency of the second AC voltage outputted by the second oscillating circuit **260**, that is, the second frequency Fq**2**. Assume that at this time the third AC voltage has a second amplitude Vam**2**.

As shown in FIG. **2**, in addition to the lamp **295**, the lamp circuit **290** further includes an equivalent capacitor C**3**. The capacitor C**3** has a first impedance Z**1** and the lamp **295** has a second impedance Z**2**. If the power provided by the third AC voltage Vac**3** is W**1**, the lamp **295** will not get all the power W**1**. The power the lamp **295** will get is W**1**×cos θ; the remaining power W**1**×sin θ will be consumed by the capacitor C**3**. The term cos θ is referred to as a power factor of the lamp **295**. The value of the power factor cos θ will be as follows:

$$\cos\theta = \frac{|Z2|}{\sqrt{Z1^2 + Z2^2}}$$

The bigger the power factor cos, the more power the lamp **295** can get from the third AC voltage Vac**3**.

It is obvious that the first impedance Z**1** of the capacitor C**3** is:

$$Z1 = \frac{1}{2\pi \cdot f \cdot C}.$$

Wherein f is the frequency of the third AC voltage Vac**3** and C is the capacitance of the capacitor C**3**. The larger the frequency f of the third AC voltage Vac**3** has, the smaller the first impedance Z**1** will be, and the bigger the power factor cos θ will be. As a result, the lamp **295** can get more power from the third AC voltage Vac**3**.

Hence if the second frequency Fq**2** is larger than the first frequency Fq**1** (with the assumption the second amplitude Vam**2** is not smaller than the first amplitude Vam**1**), the third AC voltage Vca**3** with the second frequency Fq**2** can provide more power to the lamp **295** than the third AC voltage Vca**3** with the first frequency Fq**1** can provide. If the third AC voltage Vca**3** with the second frequency Fq**2** is passed to the lamp circuit **290**, the lamp **295** can get more power, so the starting process will be completed very fast.

In this embodiment, the parameters of the elements in the first oscillating circuit **250** and the second oscillating circuit **260** must be designed properly in order to make the second frequency Fq**2** of the second AC voltage generated by the second oscillating circuit **260** to have a larger value than the first frequency Fq**1** of the first AC voltage generated by the first oscillating circuit **250**. During the starting state of the lamp **295**, the switch **230** passes the DC voltage Vdc from the power-input node **231** to the second oscillating circuit **260**; after the lamp **295** enters the normal luminescent state, the switch **230** switches to pass the DC voltage Vdc from the power-input node **231** to the first oscillating circuit **250**. The lamp **295** can get larger amount of power during the starting state, so the starting process will be completed quickly.

Please refer to FIG. **3** where an embodiment circuit diagram of the inverter **220** is illustrated. In this embodiment the first oscillating circuit **250** includes: a first capacitor **351** coupled between a first node **350** and a second node **352**; a first resistor **353** coupled between a third node **354** and a fourth node **356**; a second resistor **355** coupled between the third node **354** and a fifth node **358**; a first transistor **357** having a first end coupled to the first node **350**, a second end coupled to the fourth node **356**, and a third end coupled to ground; and a second transistor **359** having a first end coupled to the second node **352**, a second end coupled to the fifth node **358**, and a third end coupled to ground.

The second oscillating circuit **260** includes: a second capacitor **361** coupled between a sixth node **360** and a seventh node **362**; a third resistor **363** coupled between an eighth node **364** and a ninth node **366**; a fourth resistor **365** coupled between the eighth node **364** and a tenth node **368**; a third transistor **367** having a first end coupled to the sixth node **360**, a second end coupled to the ninth node **366**, and a third end coupled to ground; and a fourth transistor **369** having a first end coupled to the seventh node **362**, a second end coupled to the tenth node **368**, and a third end coupled to ground.

As mentioned before, in this embodiment the parameters of the elements in the first oscillating circuit **250** and the second oscillating circuit **260** must be properly arranged so that the second frequency Fq**2** of the second AC voltage generated by the second oscillating circuit **260** is larger than the first frequency Fq**1** of the first AC voltage generated by the first oscillating circuit **250**. Please notice that the circuit diagram shown in FIG. **3** only serves as an example; in reality the elements of the first oscillating circuit **250** and the second oscillating circuit **260** do not necessarily have to be exactly the same as what is shown in FIG. **3**. The real circuit design is left to the circuit designer as a design choice.

Also in this embodiment is the transformer **270** which includes: a first coil **371** coupled between the first node **350** and the third node **354**; a second coil **372** coupled between the third node **354** and the second node **352**; a third coil **373** coupled between the fifth node **358** and the fourth node **356**; a fourth coil **375** coupled between the sixth node **360** and the eighth node **364**; a fifth coil **376** coupled between the eighth node **364** and the seventh node **362**; a sixth coil **377** coupled between the tenth node **368** and the ninth node **366**; and a seventh coil **374** coupled between a first end and a second end of the lamp circuit.

With the transformer **270** depicted above, the first AC voltage generated by the first oscillating circuit **250** or the second AC voltage generated the second oscillating circuit **260** will be transformed to become the third AC voltage Vac**3** and then passed to the lamp circuit **290**.

In addition, the present invention of the inverter can further use different DC voltages with different values as power source. Please refer to FIG. **4** where an alternative embodiment block diagram of the present invention is illustrated. Different from FIG. **2**, in FIG. **4** a power supply **410** can provide an inverter **420** with two DC voltages of different values. The inverter **420** further includes a second switch **435**, coupled between the power supply **410** and a power-in node **431**, for selectively passing a first DC voltage **V1** or a second DC voltage **V2** provided by the power supply **410** to the power-in node **431**. The switch **435** and the switch **430** work together to decide whether the first DC voltage **V1** or the second DC voltage **V2** will be passed to the node **432** for a first oscillating circuit **450** to utilize, or to the node **433** for a second oscillating circuit **460** to utilize. Please notice that in actuality, the power supply **410** can provide more than two DC voltages to the inverter **420**, and the switch **435** can have more than two switching states for increased controlling ability on the lamp circuit **490**.

The inverters discussed above can be used in a scanner, a fax machine, or a multi-function peripheral to provide AC voltages to a lamp in that device.

In contrast to the prior art, the present inverter can provide AC voltages with two different frequencies to a lamp circuit having a lamp. Because the system uses an AC voltage with a higher frequency rather than a larger amplitude to start up the lamp, the lamp will not be damaged, and the lifetime of the lamp will not be shortened.

Those skilled in the art will readily observe that numerous modification and alternation of the device may be made while retaining the teaching of the invention. Accordingly, the above disclosure should be construed as limited only by the metes and bounds of the appended claims.

What is claimed is:

1. An inverter for providing AC voltages having two different frequencies to a lamp circuit, the inverter comprising:

a first switch for passing a DC voltage;

a first oscillating circuit coupled to the first switch for receiving the DC voltage and generating a first AC voltage having a first frequency;

a second oscillating circuit coupled to the first switch for receiving the DC voltage and generating a second AC voltage having a second frequency;

a second switch coupled between a power supply and the first switch for passing the first DC voltage or a second DC voltage provided by the power supply to the first switch as the DC voltage; and

a transformer coupled to the first oscillating circuit and the second oscillator for transforming the first AC voltage provided by the first oscillating circuit or the second AC voltage provided by the second oscillator into a third AC voltage and passing the third AC voltage to the lamp circuit;

wherein the first switch selectively passes the DC voltage to the first oscillating circuit or the second oscillating circuit.

2. The inverter of claim **1**, wherein the first switch is coupled to the power supply for receiving the DC voltage provided by the power supply.

3. The inverter of claim **1**, wherein the first oscillating circuit comprises:

a first capacitor coupled between a first node and a second node;

a first resistor coupled between a third node and a fourth node;

a second resistor coupled between the third node and a fifth node;

a first transistor having a first end coupled to the first node, a second end coupled to the fourth node, and a third end coupled to ground; and

a second transistor having a first end coupled to the second node, a second end coupled to the fifth node, and a third end coupled to ground.

4. The inverter of claim **3**, wherein the transformer comprises:

a first coil coupled between the first node and the third node;

a second coil coupled between the third node and the second node;

a third coil coupled between the fifth node and the fourth node; and a seventh coil coupled between a first end and a second end of the lamp circuit.

5. The inverter of claim **1**, wherein the second oscillating circuit comprises:

a second capacitor coupled between a sixth node and a seventh node;

a third resistor coupled between an eighth node and a ninth node;

a fourth resistor coupled between the eighth node and a tenth node;

a third transistor having a first end coupled to the sixth node, a second end coupled to the ninth node, and a third end coupled to ground; and

a fourth transistor having a first end coupled to the seventh node, a second end coupled to the tenth node, and a third end coupled to ground.

6. The inverter of claim **5**, wherein the transformer comprises:

a fourth coil coupled between the sixth node and the eighth node;

a fifth coil coupled between the eighth node and the seventh node;

a sixth coil coupled between the tenth node and the ninth node; and

a seventh coil coupled between a first end and a second end of the lamp circuit.

7. The inverter of claim **1**, wherein the inverter is used in a scanner, a multi-function peripheral, or a fax machine.

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